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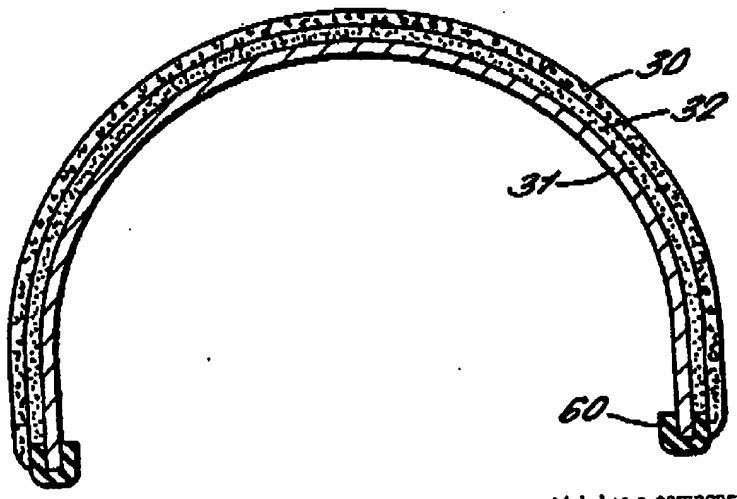
(57) Abstract

With reference to Figure 6, the present invention provides protective headgear comprising: a shell (31) having an inwardly facing surface which in use faces the head of a user of the headgear and an outwardly facing surface which in use faces away from the head of the user; and an outer membrane (30) which overlies at least a portion of the outwardly facing surface of the shell (31) and which is more flexible than the shell (31). The headgear is constructed in such a way that when a force is applied to an outer surface of the headgear which acts to rotate the headgear and the head of the user, the force can cause the outer membrane (30) to move relative to the shell. With reference to Figure 9, the present invention also provides protective armour comprising: a first layer (102) of a first flexibility having a first surface (102A) which in use is presented to receive impact blows; and a membrane (103) which overlies at least a portion of the first surface (102A) of the first layer (102) and which is more flexible than the first layer (102) of material. The protective armour is constructed in such a way that when a force is applied to an outwardly facing surface of the protective armour which has a component tangential to the surface, the force can cause the membrane (103) to move relative to the first layer (102) of material. The present invention further provides methods of modifying existing protective headgear or armour to headgear or armour according to the invention.



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PROTECTIVE HEADGEAR AND PROTECTIVE ARMOUR AND A METHOD OF MODIFYING PROTECTIVE HEADGEAR AND PROTECTIVE ARMOUR

This invention relates to protective headgear, such as safety helmets for use by motor cyclists, pedal cyclists or climbers, as well as in other hazardous sports. It is also relevant in the industrial context, for example factories, on constructions sites, defence and military applications or underground and may also have application in other areas where a protective form of headgear is necessary or required, which is effective in reducing or preventing head injury, while being lightweight and unencumbering to the wearer. A particular feature of the present invention is its ability to mimic the characteristics of the human head, in order to provide the desired protection against injury.

The present invention also relates to protective armour, for instance the body armour used by riot police and the armed forces.

Until now all designs for head protection have sought to diffuse and spread the impact of falls or blows by constructing protective helmets of hard materials with a limited degree of elasticity for energy absorption. Interior designs have consisted of webbing support, a variety of foams or a combination of the two, many of which have allowed the head to come into contact with the hard material itself on severe impact.

The invention takes note of and incorporates most of the protective features of the human head, which of itself provides large energy dissipation and protection against direct and tangential forces. The

major features of the human head are:

The scalp

This is a firm, fibrous, elastic layer with great energy absorbing characteristics. Of particular importance is the fact that it is not attached firmly to the skull, but because of being "fixed" only at the periphery, it may move on the skull by distances of up to one centimetre thus absorbing considerable amounts of energy before it begins to tear. In impacts perpendicular to the surface of the head, its fibrous elasticity allows compression and energy absorption.

The Skull

The human skull is composed of two layers of dense, compact bone "sandwiching" a layer of spongy cancellous bone (Fig. 1). This provides a hard surface for energy dissipation and absorption whilst allowing a degree of compression or crushing of the cancellous bone with more energy absorption. The cancellous bone may also allow a degree of distortion before any fracture occurs.

The Cerebro-Spinal Fluid

The fluid surrounding the brain acts as a further energy absorbing element, cushioning the brain in movements within the cranium. Lateral blows or impacts project the brain towards the cranium and the displacement of the incompressible cerebro-spinal fluids acts as a decelerating force.

In one aspect the present invention provides protective headgear comprising:

a shell having an inwardly facing surface which

in use faces the head of a user of the headgear and an outwardly facing surface which in use faces away from the head of the user,

an outer membrane which overlies at least a portion of the outwardly facing surface of the shell and which is more flexible than the shell, wherein

the protective headgear is constructed in such a way that a force applied to an outer surface of the headgear which acts to rotate the headgear and the head of the user can cause the outer membrane to move relative to the shell.

Preferably the membrane is composed of an energy absorbing and compressive material and preferably the material is elastic. Preferably the membrane is connected to the remainder of the protective headgear along a lower edge of the protective headgear and the membrane can extend to allow relative motion between the membrane and the shell.

In one embodiment the membrane comprises a high density foam material. Preferably the shell comprises a carbon fibre composite material.

The headgear can comprise an inner layer which can incorporate a deformable cellular material such as an inner lining member of low density foam. The inner lining member alternatively could comprise a further energy absorbing element in the nature of a flexible sac. The flexible sac can be filled with a liquid of predetermined viscosity which can flow around the sac when the headgear suffers impact in order to damp motion of a head in the headgear relative to the hard shell. The inner liner can comprise cellular material in combination with a fluid filled sac. The fluid filled sac can be subdivided into a plurality of compartments or cells to control fluid placement

within the sac and preferably the compartments or cells are interconnected with flow regulating passages.

In a preferred embodiment an intermediate layer is interposed between the hard shell and the outer layer, the intermediate layer facilitating relative movement between the shell and outer layer. The intermediate layer may be incorporated integrally in the outer membrane. The intermediate layer may comprise a friction reducing material or lubricant agent which facilitates the movement between the outer layer and he helmet shell.

The membrane preferably overlies the entire outwardly facing surfaces of the shell and is preferably impervious to moisture.

In further embodiments of the invention, the headgear can additionally comprise acoustic or visual protection means and the headgear can also include ventilation means to improve comfort.

In this specification it should be understood that the words outer and inner are used to specify position relative to the hard shell of the headgear.

In a second aspect the present invention provides protective armour comprising:

a first layer of material of a first flexibility having a first surface which in use is presented to receive impact blows, and

a membrane which overlies at least a portion of the first surface of the first layer and which is more flexible than the first layer of material, wherein

the protective armour is constructed in such a way that when a force is applied to an outwardly

facing surface of the protective armour which has a component tangential to the outer surface, the force can cause the membrane to move relative to the first layer of material.

Preferably the membrane is compressible and elastic and can absorb energy when compressed.

Preferably the membrane is connected to the remainder of the protective armour by elastic connection means which can extend to allow relative motion between the membrane and the first layer.

Preferably the membrane comprises high density foam.

Preferably the protective armour comprises a layer intermediate between the first layer and the membrane, the intermediate layer facilitating relative movement between the membrane and the first layer. Preferably the intermediate layer comprises a lubricant material. Alternatively the intermediate layer has a first surface which can abut the membrane and a second surface which can abut the first surface of the first layer of material, the first and second surfaces of the intermediate layer each having a low coefficient of friction.

Preferably the first layer of material comprises a carbon fibre composite material.

The protective armour can be used as body armour.

According to a third aspect, the present invention provides protective headgear comprising first and second securing straps for securing the remainder of the head gear on a head of a user, where the first strap can pass under the chin of the user to act as a

chin restraint and the second strap can pass around the lower part of the back of the head of the user to act as an occipital restraint.

The present invention further provides a method of modifying existing protective headgear wherein a membrane is attached to the remainder of the headgear to overlie at least a portion of the original outer surface of the protective headgear so as to provide a new outer surface for the protective headgear, the membrane being attached to the remainder of the headgear in such a way that when a force is applied to the outer surface of the membrane which acts to rotate the protective headgear the force can cause the membrane to move relative to the remainder of the headgear.

The present invention additionally provides a method of modifying existing protective armour wherein a membrane is attached to the remainder of the armour to overlie at least a portion of the original outer surface of the protective armour so as to provide a new outer surface for the protective armour, the membrane being attached to the remainder of the armour in such a way that when a force is applied to the outer surface of the membrane which acts tangential to the membrane, the force can cause the membrane to move relative to the remainder of the protective armour.

Preferred embodiments of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 illustrates the structure of the human skull;

Figures 2a and 2b illustrate chin straps for headgear according to the invention;

Figure 3 is a cross-section of a first preferred embodiment of headgear according to the invention;

Figure 4 is a cross-section of a second preferred embodiment of headgear according to the invention;

Figure 5 is a cross-section of a third preferred embodiment of headgear according to the invention.

Figure 6 is a cross-section of a fourth preferred embodiment of headgear according to the invention;

Figure 7 is a cross-section of a fifth preferred embodiment of headgear according to the invention;

Figure 8 is a cross-section of a sixth preferred embodiment of headgear according to the invention;

Figure 9 is a schematic illustration of body armour according to the present invention

Figure 10 is a cross-section through the body armour of Figure 9.

In Figure 3 there can be seen protective headgear in the form of a helmet which has a hard shell 10 and an outer energy absorbing compressible layer 11, resembling the scalp and reproducing its protective function. This layer 11 consists of a fibrous and/or elastic material, resembling carpet tiling or plastic foam. Thick leather would also have some of the envisaged qualities but cost and weight may be determining factors in which a case synthetic material with similar properties would be used. Since the outer soft covering layer 11 could be a porous material it must be rigorously waterproofed as absorbed water would reduce its energy absorbing

qualities. This could be achieved by treatment of the material or by the superimposition of a thin but durable layer or by both methods.

To reproduce the energy absorbing qualities of the scalp the attachment of the outer energy absorbing compressible layer 11 to the hard shell 10 is critical. It will be bonded to the hard shell 10 of the helmet around the edge of the hard shell 11, in a way chosen in dependence on the physical characteristics of the materials chosen for the headgear. The layer 11 will be bonded only at the edge of the hard shell 10 in order to allow relative motion between the outer energy absorbing layer 11 and the hard shell 10 in order to mimic the protective movement of the scalp. The outer layer 11 can stretch to allow relative motion. A lubricant 12 between the energy absorbing layer and the shell may be beneficially used.

It is preferred that the hard shell 10 itself is a sandwiched material with hard outer layers sandwiching a deformable inner layer. Otherwise a single layer material of plastic, fibreglass or other appropriate material will be used but with hardness and deformability characteristics matched to the new construction and yielding optimum protection on standard or newly developed testing.

To mimic the fluid suspension provided by the cerebro-spinal fluid, a flexible sac 13, filled with an appropriately viscous liquid will be bonded to the inner surface of the hard shell 10. Since fluid in a unicellular sac would gravitate to the brim, compartmentalisation will be necessary and to allow displacement under impact. Flow control mechanisms between compartments will be included to control flow

between the compartments. The flow control mechanism will not allow flow of fluid between compartments in normal use, but will allow flow of fluid between compartments when the helmet is subject to an impact (the interconnection of the compartments allows development of a uniform pressure in all of the compartments, thereby spreading an impact over a large area). The fluid in the layer 13 may be a viscous or aqueous fluid and will act to damp motion of the helmet relative to the head of a user when the helmet is subject to an impact. The flow control could comprise lines of weakness in walls dividing the compartments, the walls remaining intact to seal off the compartments in normal use, but the lines of weakness breaking to form apertures in the walls (and thus to allow flow of fluid) in impact conditions. An alternative embodiment will be a "bubble pack" type lining, with liquid, liquid and gas combined or solely gas filling.

A thin polystyrene liner bonded to the inner surface of the sac could alternatively be used to maintain the shape of and thus the fluid distribution within the sac in which case compartmentalisation will not be necessary used.

Figure 6 shows how an outer membrane 30 of closed cell plasticised Polyvinyl Chloride (PVC) can be attached to a carbon fibre composite shell 31 in order to permit relative motion between the membrane 30 and the shell 31. For the sake of simplicity inner layers within the shell 31 (e.g. a head liner) are not shown.

The outer membrane 30 is attached to an inner surface of the shell 31 around the edge of the shell 31 via an

intermediary band 60 of a compliant material. An epoxy adhesive is used to bond the intermediary band 60 to the inner surface of the shell 31 around the lower edge. The intermediary band 60 is adhered to the inner surface and then extends down around the lower edge and then upwardly around the exterior of the lower part of the shell 31. The outer membrane 30 is adhered by an adhesive to the part of the intermediary band that overlies the outwardly facing lower edge of the shell 31. The intermediary band 60 will be made of a material of greater compliance than the outer membrane 30. The membrane 30 is attached to the shell 31 only via the intermediary band 60 and thus the remainder of the membrane 30 is free to move relative to the underlying shell. Both the membrane 30 and the intermediary band 60 can stretch on application of a force to allow relative motion between the membrane 30 and the shell 31.

A layer 32 of a lubricant gel is enclosed between the membrane 30 and the shell 31 and this facilitates relative movement between the membrane 30 and the shell.

A further embodiment of helmet is illustrated in Figure 7. In this embodiment an outer membrane 40 of polyethylene is attached to the interior of a glass fibre shell 41 via an intermediary band 61 adhered to the bottom edge of the interior of the glass fibre shell 41. The membrane 40 is attached to the shell 41 only via the band 61 thus the membrane 40 is otherwise free to stretch and move relative to the shell 41. The band 61 is composed of a material which is more compliant that the outer membrane 40 and also stretches to allow relative motion. The relative movement is assisted by the interposition of a PTFE layer 42 between the membrane 40 and the shell 41;

the surfaces of the PTFE layer having a low coefficient of friction.

An additional embodiment of helmet is illustrated in Figure 8. In this embodiment a membrane 50 of ethylene vinyl acetate co-polymers is attached to the interior of a glass reinforced plastic (GRP) shell 51, the membrane 50 being adhered directly to the interior bottom edge of the shell 51. The inwardly facing surface of the membrane 50 is treated to reduce the coefficient of friction of the surface and the outwardly facing surface of the GRP shell is also treated to reduce the coefficient of friction of the surface. Since the membrane 50 is only attached to the shell 51 at the lower edge, the membrane 50 is free to stretch and move relative to the shell 51, assisted by the low coefficient of friction of the abutting surfaces of the membrane 50 and the shell 51.

The inwardly facing surface of the membrane 50 and the outwardly facing surface of the shell 51 in this embodiment can incorporate a lubricant to dispense with the need for an intermediary layer such as a lubricant gel.

Other less preferred materials for the outer membrane include cross-linked high density polyurethane foam and silicon foamed rubber.

Testing has been carried out on embodiments of helmet according to the invention. In each case a standard full faced GRP helmet was tested and then another of the same type of GRP helmet was modified by covering the helmet with a membrane, in accordance with the invention. Each helmet was fitted to a head form with an array of nine accelerometers and then dropped on to a test anvil with an impact surface comprising

aluminium oxide paper, 80 grit. The impact velocity was 8.5 m/s and the impact site on the right or left hand side of the helmet.

Very significant reductions were achieved in the maximum tangential force ON the head form in the helmet. Also a moderate decrease in the maximum linear acceleration forces were achieved.

The combination of materials for the headgear will be chosen bearing in mind that the sound insulation qualities of the combination may represent a hazard in motorcycle or cycle applications. It is always possible to provide perforations in the ear area of the headgear.

In military/aeronautical applications additional material or earcups would provide noise protection and additional protection against lateral blows which tend to cause fractures of the base of the skull. Also visual protection and enhancement devices could be incorporated in the helmet and also respiratory devices such as gas masks and air purifiers. The illustrated embodiment in Figure 3 has a fitting band 14.

Since the heat insulation qualities of the described helmets could be high if certain material combinations are chosen, provision must be made for ventilation in appropriate weather conditions. Inlet and outlet ports will be provided with variable control of the air inlet and consideration will given to the provision of ventilation ports on the vertex in applications where there is no generated air flow.

In many accidents, particularly in industrial mishaps involving a fall, the helmet is flung off. The

retention system is therefore, a critical element of head protection. On each side of the helmet there would be preferably a two point attachment, one in front of the other behind the central transverse vertical plane. Depending on the shape of the helmet and the application, there would be either a double strap 15 joined to form a chin cup 16 as shown in Figure 2a or a single strap 17,18 from each point of attachment, the interior one providing a chin restraint and the posterior an occipital restraint as shown in Figure 2b.

Modifications of the headgear of Figure 3 are shown in Figures 2a and 2b. One modification omits the flexible sac 13 and comprises two layers of plastic foam, in combination with a polystyrene liner, either both outside the polystyrene liner (see Figure 5 where two layers of plastic foam 19 and 20 are both outside a polystyrene liner 21) or one outside and the other inside the polystyrene liner (see Figure 4 where one layer of plastic foam 22 is inside a polystyrene liner 23 and one layer of plastic foam 24 is outside the polystyrene liner 23). These foam layers can be either low density or combinations of low and higher density foams.

Severe head injuries continue to occur despite the use of current protective headgear and, in American industry alone, involve national costs amounting to billions of dollars. Many of these injuries result from falls in which the helmet falls off; similarly there are still many motor cycle injuries resulting from the same cause. This is quite apart from those injuries caused by inadequate protection from existing design of head protection.

A major improvement, therefore, will be achieved by

conversion of existing hard hat to hats with "soft" outer skins according to the invention, preferably with the provision of effective retention systems. Soft covers and new retention systems designed for attachment to existing headgear are included in the scope of the invention.

Whilst above the present invention is described with reference to its use for protective headgear, the invention can also be applied to protective armour, such as body armour. The same principle of using an overlying membrane can be used. Shown in Figure 6 is protective armour in the form of a breast plate 100 which can be worn in front of a user secured by straps 101.

The breast plate 100 comprises a first layer 102 made of fibre glass (or carbon fibre, a metal or a plastic) which has a first surface 102A in use is presented to receive impact blows. The armour has also a compliant elastic membrane 103, for instance of closed cell plasticised Polyvinyl Chloride (or of polyethylene, ethylene vinyl acetate co-polymers, cross linked high density polyurethane foam or silicon foamed rubber. This membrane in use overlies the first surface 102A of the first layer 102. The membrane 103 is more flexible than the first layer 102 and is compressible and elastic and can absorb energy when compressed.

The membrane 103 is connected to the first layer 102 by an intermediary band 104 of an elastic material.

The intermediary band 104 is adhered around the edge of a face 102B of the first member 102 (the face 102B facing in the opposite direction to the face 102A). The intermediary band 104 extends around the edge of the first member of the 102 and overlies an edge

portion of the surface 102A. The intermediary band 104 is only adhered to the first member 102 on the surface 102B thereof. The membrane 103 is adhered around its periphery to the intermediary band 104.

An intermediary layer 105 of lubricant gel is included between the membrane 103 and the first layer 102 and facilitates relative motion between them. This layer is not essential and could be replaced by a solid layer of a material of a low co-efficient of friction (e.g. a layer of PTFE). Alternatively a lubricant could be incorporated into the inner surface of the membrane 103.

The protective armour is constructed in such a way that when a force is applied to the outwardly facing surface of the membrane 103 which has a component tangential to the outer surface, tha force can cause the membrane 103 to move relative to the first layer 102.

The present invention also provides a method of modifying protective armour comprising providing "soft" outer skin to cover an existing plate.

CLAIMS

1. Protective headgear comprising:

a shell having an inwardly facing surface which in use faces the head of a user of the headgear and an outwardly facing surface which in use faces away from the head of the user,

an outer membrane which overlies at least a portion of the outwardly facing surface of the shell and which is more flexible than the shell, wherein

the protective headgear is constructed in such a way a force applied to an outer surface of the headgear which acts to rotate the headgear and the head of the user can cause the outer membrane to move relative to the shell.

2. Protective headgear as claimed in claim 1 wherein the outer membrane is compressible and elastic and the outer membrane can compress in response to a force applied to the headgear to thereby absorb energy.

3. Protective headgear as claimed in claim 1 or claim 2 wherein the outer membrane is elastic.

4. Protective headgear as claimed in any one of the preceding claims wherein the outer membrane is connected to the remainder of the protective headgear along a lower edge of the protective headgear and the membrane can extend to allow relative motion between the membrane and the shell.

5. Protective headgear as claimed in claim 4 wherein the outer membrane is connected to the remainder of the headgear only via an elastic intermediate member.

6. Protective headgear as claimed in claim 5 wherein

the elastic intermediate member is more compliant than the outer membrane.

7. Protective headgear as claimed in any one of the preceding claims wherein the membrane comprises closed cell plasticised polyvinyl chloride.

8. Protective headgear as claimed in any one of claims 1 to 6 wherein the membrane comprises polyethylene.

9. Protective headgear as claimed in any one of claims 1 to 6 wherein the membrane comprises ethylene-vinyl acetate co-polymers.

10. Protective headgear as claimed in any one of the preceding claims wherein the shell comprises a carbon fibre composite material.

11. Protective headgear as claimed in any one of the preceding claims comprising additionally a layer of incompressible fluid located in use between the shell and the head of the user and encapsulated in a flexible sac.

12. Protective headgear as claimed in claim 11 wherein the flexible sac containing the compressible fluid is compartmentalised into a plurality of compartments and the flexible sac comprises connection means connecting each compartment to at least one other compartment, the connection means being operable to prevent flow of fluid from one compartment to another until an impact on the protective headgear exceeds a threshold value at which point the connection means allows flow of fluid between the chambers.

13. Protective headgear as claimed in claim 12 wherein the incompressible fluid is a fluid which resists flow between compartments in order to damp motion of the shell.

14. Protective headgear as claimed in any one of the preceding claims comprising additionally a layer of low density foam located in use between the shell and the head of the user.

15. Protective headgear as claimed in any one of the preceding claims comprising an intermediate layer interposed between the shell and the membrane, the intermediate layer facilitating relative movement between the membrane and the shell.

16. Protective headgear as claimed in claim 15 wherein the intermediate layer is a layer of lubricant material.

17. Protective headgear as claimed in claim 15 wherein the intermediate layer has a first surface which can abut the membrane and a second surface which can abut the shell and the first and second surfaces each have a low coefficient of friction.

18. Protective headgear as claimed in any one of the preceding claims wherein the membrane overlies the entire outwardly facing surface of the shell.

19. Protective headgear as claimed in claim 18 wherein the membrane is impervious to moisture.

20. Protective headgear as claimed in any one of claims 1 to 18 comprising additionally a moisture resistant outer covering overlaying the membrane.

21. Protective headgear as claimed in any one of the preceding claims comprising additionally acoustic protection means.

22. Protective headgear as claimed in any one of the preceding claims comprising additionally visual protection and enhancement means.

23. Protective headgear as claimed in any one of the preceding claims comprising additionally ventilation means.

24. Protective headgear as claimed in any one of the preceding claims comprising first and second securing straps for securing the headgear on the head of the user, the first strap providing chin restraint and the second strap providing an occipital restraint.

25. Protective armour comprising:

a first layer of material of a first flexibility having a first surface which in use is presented to receive impact blows, and

a membrane which overlies at least a portion of the first surface of the first layer and which is more flexible than the first layer of material, wherein

the protective armour is constructed in such a way that when a force is applied to an outwardly facing surface of the protective armour which has a component tangential to the outwardly facing surface, the force can cause the membrane to move relative to the first layer of material.

26. Protective armour as claimed in claim 25 wherein the membrane is compressible and elastic and can absorb energy when compressed.

27. Protective armour as claimed in claim 25 or

claims 26 wherein the membrane is connected to the remainder of the protective armour by elastic connection means which can extend to allow relative motion between the membrane and the first layer.

28. Protective armour as claimed in any one of claims 25 to 27 wherein the membrane comprises closed cell plasticised polyvinyl chloride.

29. Protective armour as claimed in any one of claims 25 to 27 wherein the membrane comprises polyethylene.

30. Protective armour as claimed in any one of claims 25 to 27 wherein the membrane comprises ethylene-vinyl acetate co-polymers.

31. Protective armour as claimed in any one of claims 25 to 30 which comprises a layer intermediate between the first layer and the membrane, the intermediate layer facilitating relative movement between the membrane and the first layer.

32. Protective armour as claimed in claim 31 wherein the intermediate layer comprises a lubricant material.

33. Protective armour as claimed in claim 31 where the intermediate layer has a first surface which can abut the membrane and a second surface which can abut the first surface of the first layer of material, the first and second surfaces of the intermediate layer each having a low coefficient of friction.

34. Protective armour as claimed in any one of claims 25 to 33 when the first layer of material comprises a carbon fibre composite material.

35. Protective armour as claimed in any one of claims

25 to 34 for use as body armour.

36. Protective headgear comprising first and second securing straps for securing the remainder of the headgear on a head of a user, where the first strap can pass under the chin of the user to act as a chin restraint and the second strap can pass around the lower part of the back of the head of the user to act as an occipital restraint.

37. A method of modifying existing protective headgear wherein a membrane is attached to the remainder of the headgear to overlie at least a portion of the original outer surface of the protective headgear so as to provide a new outer surface for the protective headgear, the membrane being attached to the remainder of the headgear in such a way that when a force is applied to the outer surface of the membrane which acts to rotate the protective headgear and the head, the force can cause the membrane to move relative to the remainder of the headgear.

38. A method of modifying existing protective armour wherein a membrane is attached to the remainder of the armour to overlie at least a portion of the original outer surface of the protective armour so as to provide a new outer surface for the protective armour, the membrane being attached to the remainder of the armour in such a way that when a force is applied to the outer surface of the membrane which has a component tangential to the membrane, the force can cause the membrane to move relative to the remainder of the protective armour.

FIG. 1.

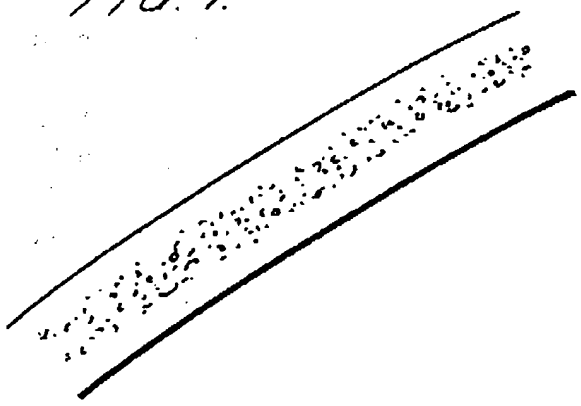


FIG. 2a.

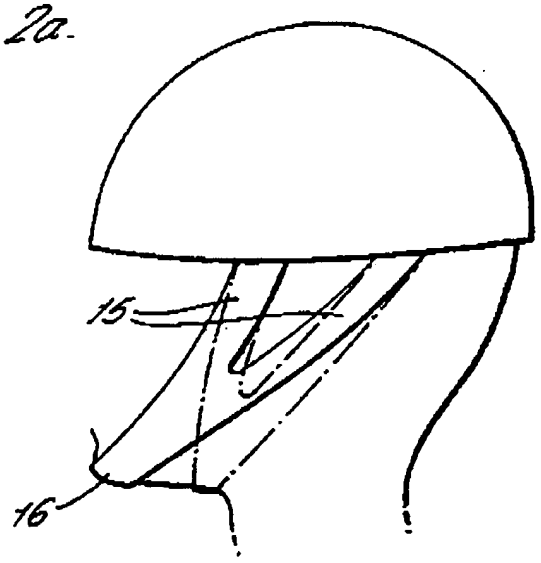


FIG. 2b.

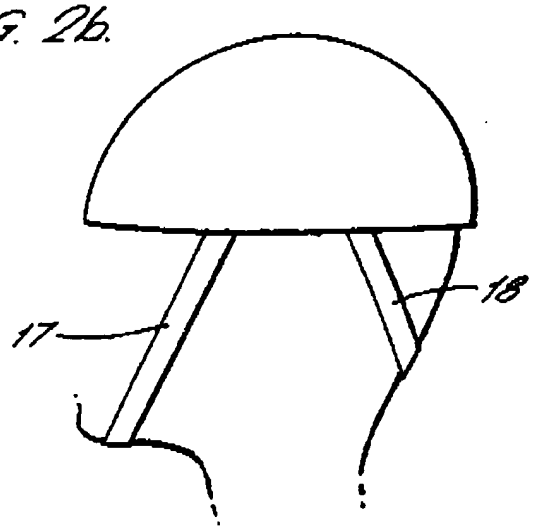


FIG. 3.

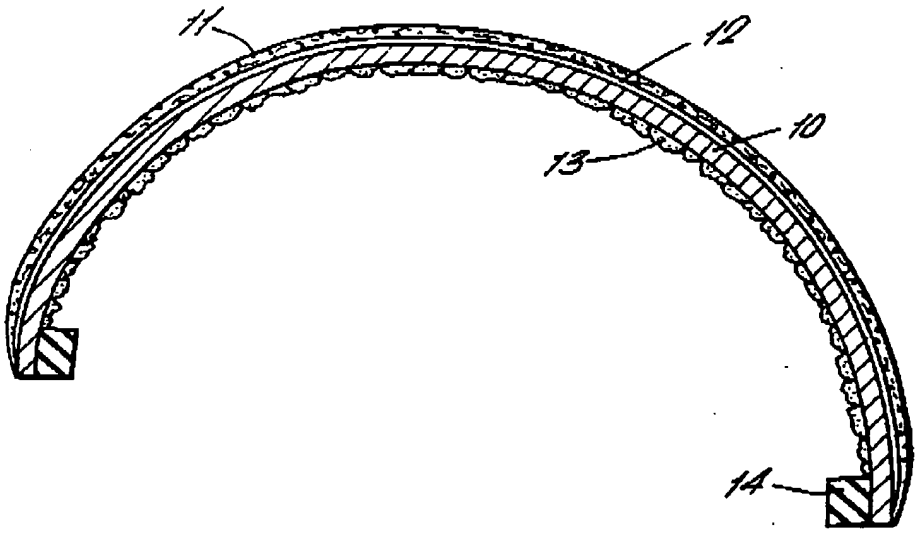


FIG. 4.

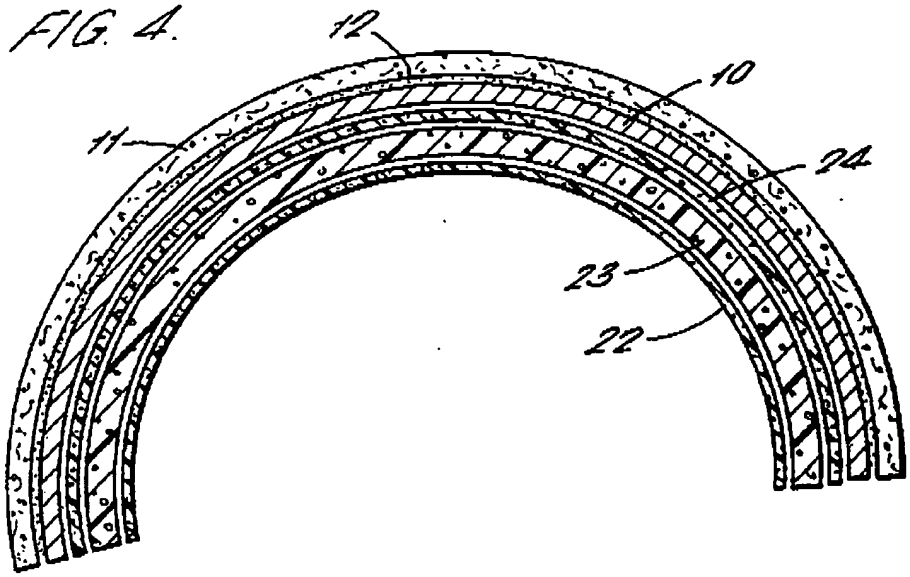


FIG. 5.

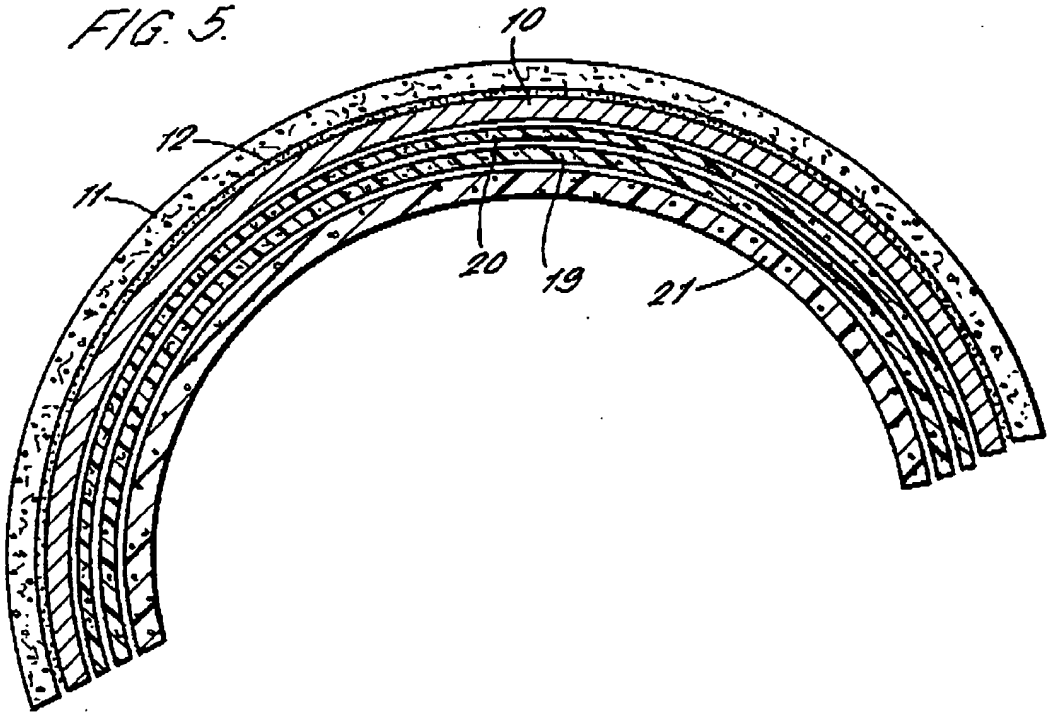
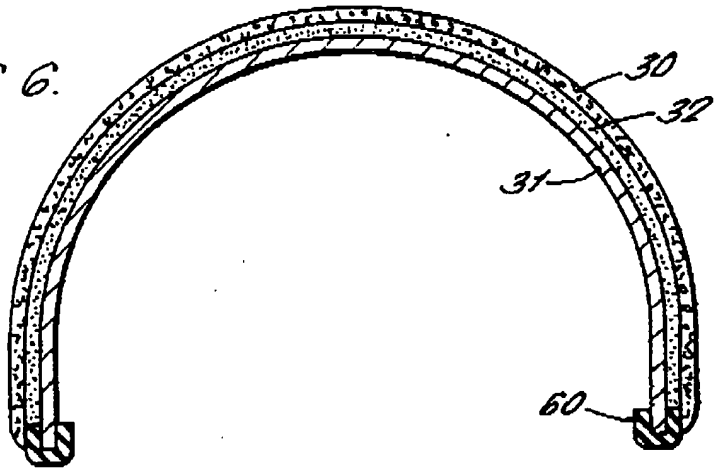


FIG. 6.



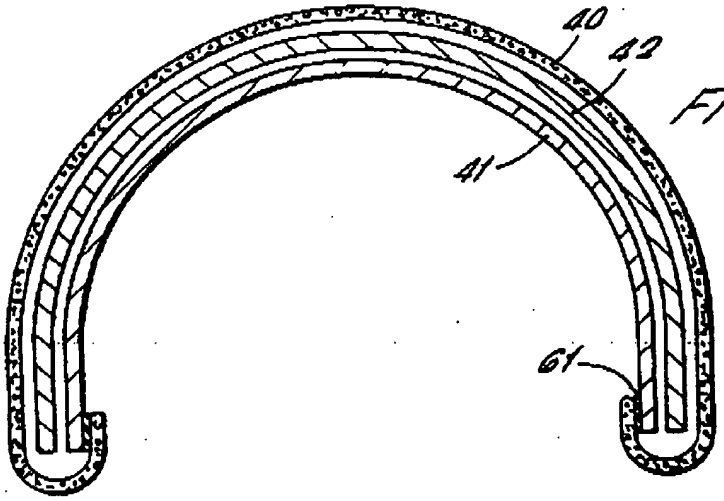


FIG. 7.

FIG. 8.

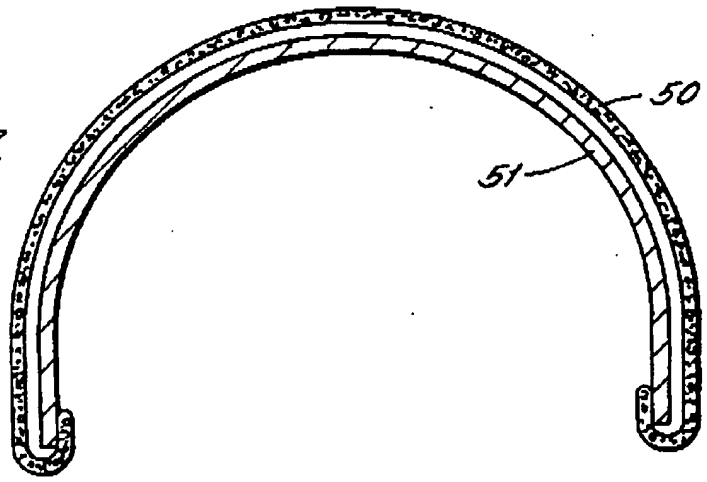
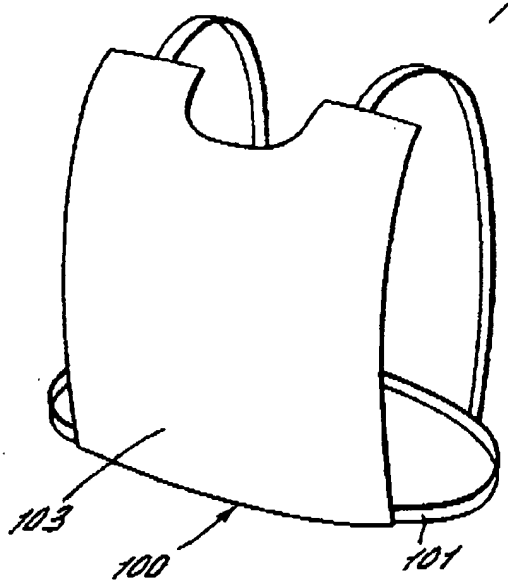


FIG. 9.



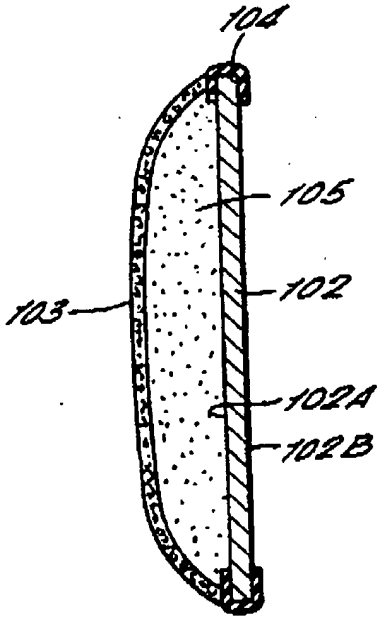


FIG. 10.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 95/02693

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A42B3/06 A42B3/12 A42B3/08 A42B3/04 A42B3/28
F41H5/04 A63B71/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A42B F41H A63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,3 242 500 (J. W. DERR) 29 March 1966 see column 1, line 40 - line 64 see column 2, line 27 - line 49 see figures 1,3	1-3,14, 18
A	---	7-10,19, 20,37
X	US,A,4 012 794 (T. NOMIYAMA) 22 March 1977 see column 1, line 41 - line 51 see column 2, lines 18 - 24, 39 - 44 see column 3, lines 32 - 50, 62 - 64 see column 5, line 16 - line 35 see figures 1,11	1,15-17
A	---	10,37
	-/--	

[X] Further documents are listed in the continuation of box C. [X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
4 March 1996	19.03.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Bourseau, A-M

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 95/02693

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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X	FR,A,2 222 034 (ROYAL INDUSTRIES, INC.) 18 October 1974 see page 5, line 1 - page 6, line 6 see page 6, line 21 - line 25 see page 7, line 10 - line 23 see page 8, line 12 - line 28 see figures 1,3	1,4,14, 18-20
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A	US,A,4 434 514 (J. G. SUNDAHL ET AL.) 6 March 1984 see abstract; claims; figures	

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INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 95/02693

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 95/02693

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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US-A-4012794	22-03-77	JP-C-	1265611	27-05-85
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AU-B-512331	02-10-80	NONE		

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